

INTERNATIONAL HARMONISED RESEARCH ACTIVITIES SIDE IMPACT WORKING GROUP STATUS REPORT

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ABSTRACT

This paper reports on the status of work of the International Harmonised Research Activities (IHRA) Side Impact Working Group (SIWG) as at its 11th meeting prior to the 17th ESV conference in Amsterdam in June 2001. This includes decisions made and the reasons for them as well as identifying outstanding issues that require resolution.

INTRODUCTION

A steering committee was set up during the 15th Enhanced Safety of Vehicles (ESV) conference in Melbourne in 1996 to work towards an agreed research agenda to avoid duplication of vehicle safety research. This is the International Harmonised Research Activities (IHRA) under which its working groups, consisting of government delegates from around the world, conduct their work. It was agreed that IHRA be responsible for overseeing research activities in six key areas.

One of the original key areas, functional equivalence, was replaced by side impact following the 16th ESV conference in Windsor, Canada in 1998. The six working groups under IHRA are shown below with each group chaired by the country in parenthesis:

- Side impact (Australia)
- Advanced frontal crash protection (Italy)
- Vehicle compatibility (United Kingdom)
- Biomechanics (USA)
- Pedestrian safety (Japan)
- Intelligent Transport Systems (Canada)

The various IHRA working groups generally consist of about 10 members to ensure that progress is as speedy as possible. Although IHRA is essentially a government group, industry has been invited with a total of three representatives in each working group, one each from North America, Europe and Asia-Pacific regions. This maximises outcomes by engaging vehicle manufacturers

in the research process so that countermeasures can be designed into vehicles as soon as possible.

Scope

The task of the IHRA SIWG is, to the degree possible to coordinate research to support the development of a globally harmonised test procedure(s) to reduce injury risk in side impact crashes. The test procedure(s) would include the best available dummies as recommended by the IHRA Biomechanics Working Group (BWG) (for example, the harmonised test dummy being developed by the ISO WorldSID Task Force (www.worldsid.org)). The BWG will also advise on availability of any other suitable test dummies and the injury criteria to be used.

The Terms of Reference of the SIWG were to co-ordinate research worldwide to support the development of future side impact test procedure(s) to maximise harmonisation with the objective of enhancing safety in real world side crashes. This would include:

1. Review of real world crash data to prioritise injury mechanisms and identify associated crash conditions taking into account likely future trends.
2. Taking into account the need to protect both front seat and rear seat(s) adult and child occupants.
3. Interaction with the IHRA Biomechanics Working Group to monitor the development of harmonised injury criteria.
4. Interaction with the IHRA offset frontal and vehicle compatibility working groups to ensure solutions in one area do not degrade safety in another.
5. Monitor and, as appropriate, provide input to the development of WorldSID and any other side impact dummy.
6. Possible additional component or sub-system test procedure(s).

Members noted that there are differences in fleet compositions around the world but were hopeful that

research could be focused on these differences to determine whether they had a quantifiable effect on the injury risk in side impacts.

Membership

The current members of the IHRA Side Impact Working Group are:

Keith Seyer	Department of Transport and Regional Services, Australia (Chair)
Craig Newland	Department of Transport and Regional Services, Australia (Secretary)
Dainius Dalmotas	Transport Canada
Suzanne Tylko	Transport Canada
Richard Lowne	EC/EEVC
Joseph Kianianthra	National Highway Traffic Safety Administration, USA
Hideki Yonezawa	Japanese Ministry of Transport
Minoru Sakurai	JARI
Takahiko Uchimura	OICA Asia-Pacific/JAMA
Michael Leigh	OICA North America/AAM
Rainer Justen	OICA Europe/ACEA

Past members:

Robert Hultman	OICA North America/AAM
Haruo Ohmae	JARI

List of Meetings

Although IHRA was created in 1996, the IHRA SIWG was only initiated in September 1998 and therefore has been operational for only the last 2 years for which IHRA has existed. The list of meetings is provided below:

Meeting	Date	Place
1 st	19 September 1998	Gothenburg, Sweden
2 nd	5 November 1998	Phoenix, Arizona, USA
3 rd	25 - 26 February 1999	London, England
4 th	17 - 18 May 1999	Kyoto, Japan
5 th	12 July 1999	Sailuf, Germany

6 th	3 - 4 November 1999	San Diego, California, USA
7 th	7 - 8 February 2000	Madrid, Spain
8 th	12 - 13 June 2000	London, England
9 th	25 - 26 September 2000	Lyon, France
10 th	11-12 December 2000	Melbourne, Australia
11 th	5-6 March 2001	Geneva, Switzerland

Location of Minutes

The Minutes of these meetings are located on the IHRA website – <http://www-ihra.nhtsa.dot.gov>

SUMMARY OF RESEARCH

Methodology

The group initially discussed whether it should look at both short and long term possibilities for harmonisation. The short-term issue was the adoption of a modified EuroSID 1 (ES-2) as an interim harmonised dummy in both US and European regulations. Feedback from the IHRA Steering Committee indicated that the group should concentrate on the development of a long-term harmonised test procedure(s) to improve side impact occupant protection. Therefore, the IHRA SIWG has concentrated its efforts on the long-term solution and has monitored the short-term efforts in the various regions.

To determine the side impact trauma problem that needed to be addressed, the group began by examining real world crashes in the 3 major geographical regions, North America, Europe and Asia-Pacific, to identify the:

- types of side impact crashes occurring
- injuries being sustained by body region
- causes of these injuries, where possible
- characteristics of the drivers and passengers most at risk (gender, size, seating position, etc)

For vehicle to vehicle crashes, members were asked to report on any research that examined the effects on injury

risk of mass, stiffness and geometry of striking vehicles together with any other parameters that were considered important for side impact protection.

The SIWG coordinated with the IHRA Biomechanics and ISO WorldSID Task Group who had been charged with developing the requirements for, and promoting the development of, a harmonised side impact test dummy(ies) suitable for use in the IHRA Side Impact Test Procedure(s). It was also agreed that there needed to be consideration of vehicle-to-vehicle compatibility in development of test procedures. As a result there has been close cooperation and communication between the SIWG and other IHRA WGs on advanced frontal, vehicle compatibility and biomechanics, and with the WorldSID Task Force.

Real World Crash Studies

As part of the IHRA BWG task to define the real world side impact safety problem, Transport Canada analysed the real world crash data submitted by the various regions. This study, which is reported in full in the IHRA BWG report, indicated that:

- Collectively, side impacts involving vehicle to vehicle crashes and vehicle to narrow object crashes constitute about 90% of the side impact trauma. However, the frequency of involvement of specific vehicle types and narrow objects varied from region to region.
- Most of the trauma in side impacts occurs to struck side occupants.
- Up to 40% of the trauma to occupants of the struck car in side crashes occurs to non-struck side occupants depending on the geographical region.
- The head and chest were consistently the most frequently injured body regions.
- The frequencies of abdominal, pelvic and lower extremity injuries were also significant, but varied with geographical region.
- The main contact points causing injury to front struck side occupants were door structure, exterior object and B-pillar.
- Depending on the region, the proportion of male and female severely or fatally injured occupants in vehicle-to-vehicle crashes were either similar or slightly predominated by females (up to 60%).
- Young males predominated in vehicle to narrow object crashes.
- Elderly occupant with serious or fatal injuries were over-represented in vehicle to vehicle crashes.
- Rear occupants account for less than 15% of road trauma in side impacts.

The above research, combined with the need to ensure enhanced side impact protection for all adult occupants, would indicate the importance of using a small adult female test device in the front driver position in an MDB to vehicle test and using a mid sized adult male test device in a vehicle to pole test. Regulators may wish to specify requirements for other dummy sizes, if crash statistics indicate such a need for a particular region.

Parametric Studies on Effect of Mass, Stiffness and Geometry on Dummy Response

In the real world, vehicles of different type size and mass crash into each other. A number of parametric studies have been conducted to examine the effect on injury risk of the mass, stiffness and geometry of the striking vehicle in side impacts. The data presented to the SIWG included results from:

- A computer simulation by the UK Transport Research Laboratory
- A cooperative project of full-scale tests by the Australian Department of Transport and Regional Services and Transport Canada.
- A full-scale test series by the US Insurance Institute for Highway Safety.
- Full scale tests by Transport Canada.
- A computer simulation by the NHTSA.
- Full-scale tests and FEM simulations of front-end structures of impacting vehicles for the comparison with current European MDB face by JAMA.
- Full scale tests by JMOT.

Based mainly on single parameter variations, these data supported the following conclusions on the factors that increased dummy response:

- Raising the vehicle/trolley ground clearance had the greatest effect.
- Increasing the mass and stiffness of the vehicle/trolley has a lesser effect.
- A perpendicular impact maximises the loadings to the driver when compared to crabbing the trolley.
- Non-homogeneous barriers generate more “punch-through” than homogeneous ones.

This is because:

- In high frontal profile vehicles such as 4WDs/Light Trucks and Vans (LTVs) there is typically less engagement of the sill and floorpan of the struck vehicle and are more likely to load the head (from

contact with the high hood/bonnet) and chest (from the higher intrusion profile).

- Typically, injuries occur (40-50 msec after impact) before momentum transfer to the struck vehicle occurs (around 70 msec).
- The stiffness ratio between the front and side structure of vehicles is so high that, for the same geometry, variation in front structure stiffness has lesser effect on dummy response.

Some of these studies also included increasing impact speed which was found to have an effect similar to increasing ground clearance. For example one of the studies showed that increasing the speed from 50 to 60 km/h had the same or similar effect on dummy responses as increasing the ground clearance from 300 mm to 400 mm.

Compound variations of mass, stiffness, geometric and velocity parameters are yet to be investigated.

CONCLUSIONS

After reviewing the available research data, members agreed to the relevance of the following test procedures to enhance side impact protection:

1. Mobile deformable barrier to vehicle test.
2. Vehicle to pole test.
3. Out-of-position side airbag evaluation test(s).
4. Sub-systems head impact test.

The following sections will discuss the degree of consensus that has been reached on each of these tests.

Mobile Deformable Barrier Test

Defining the parameters of the Mobile Deformable Barrier (MDB) test has proven to be the most challenging task for the group. The following has been proposed:

- Longitudinal velocity component of the trolley will be 50 km/h.
- Small adult female driver dummy. Advice will be sought from the IHRA Biomechanics group on a recommendation on the best dummy to use.
- Dummy(ies) to be belted.

However, there are still some significant issues that have not been determined and will require further research. These will be discussed further in this section:

- Need for a rear dummy?

- Should the trolley impact the vehicle “crabbed” or perpendicularly?
- Should the deformable barrier be homogeneous or tr to represent a real vehicle (non-homogeneous)?
- Stiffness of deformable barrier?
- Mass of trolley?
- Ground clearance and geometry of deformable barrier?
- Should there be a non-struck side test?
- Driver seat track position?
- Alignment of trolley.

Need for a rear dummy

Based on the level of road trauma (less than 15%) and occupancy rate of the rear seat this would be difficult to justify by way of a cost/benefit analysis. However, if governments are promoting the rear seat for children then we should confirm that they are protected.

The current European regulation has no rear dummy while the US regulation does. Countries currently adopting one or other of these regulations may find it difficult to move from their present positions. The group proposes that a small adult female be used if it is decided to have a dummy in the rear seat.

Should the trolley impact the vehicle “crabbed” or perpendicularly?

One argument for a crabbed test is that it represents a typical intersection crash where both vehicles are moving. Earlier research indicated that crabbing was necessary to load the rear dummy. More recent work by Transport Canada indicates that a wide ECE non-homogeneous element at 400 mm ground clearance in a perpendicular test can load the rear dummy. Test agencies indicated that the perpendicular test was easier to set up and more repeatable. Perpendicular tests maximise loadings on the driver.

The issues of whether there should be a rear dummy and whether to “crab” the impacting trolley are linked. A compromise position could be to have a barrier design that both maximises the driver loadings and is capable of loading a rear dummy in a realistic manner.

Should the deformable barrier be homogeneous or non-homogeneous?

It was generally felt that non-homogeneous elements better represented a “real vehicle” to get realistic intrusion profiles and loadings of the dummy. The only caveats were increased cost over homogeneous elements

and whether all non-homogeneous elements were stable in shear. This latter point is being investigated further.

Stiffness of deformable barrier

Research data shows stiffness has a lesser effect on injury measures than geometry. However, stiffness distribution is important in obtaining intrusion velocity/profiles that are seen in actual crashes where vehicles do not have load-bearing structure out to their full width. If it were agreed to adopt a non-homogeneous element design, future work could review the ECE R95 barrier design based on rigid wall load cell data of current fleet. Research presented to the SIWG indicates that the 6 blocks in the R95 barrier are a close approximation of a real vehicle once the stiffnesses are adjusted to reflect the current European and Japanese fleets.

Mass of trolley

Research data shows mass has a lesser effect on injury measures than geometry. The average passenger car kerb mass of the current European and Japanese fleet is between 1150-1200 kg. The average kerb mass of the US passenger car fleet is 1415 kg. The average of kerb mass of the US LTV fleet is 1920 kg. When LTVs are included in the US fleet, the average kerb mass is about 1635 kg. The Europeans have indicated they would be prepared to consider a trolley mass of up to 1500 kg in the interests of harmonisation. Japan and the US have not made a decision whether they could support a trolley mass of 1500 kg.

Ground clearance and geometry of deformable barrier

Defining the trolley ground clearance to represent actual vehicle geometry is contingent upon a detailed study of front-end structures of vehicles in different regions.

The Europeans are considering increasing the ground clearance of ECE R95 to 350 mm. However, they did not necessarily want to see the overall height of the element increase because there is no problem in Europe with high frontal profile vehicles. The US is concerned about the ever-increasing LTV population and, in particular, Sports Utility Vehicles (SUVs). Sales of these vehicles are increasing in Europe and Asia Pacific but not to the levels in the US.

In the interests of harmonisation, a single test representative of a worst case situation would be desirable. However, as the vehicle fleets differ between regions, this may not be possible. An interim solution

could be to have two tests – for example, one at 350 mm for a predominantly passenger car fleet and one at 450 mm ground clearance for the US situation. However, some members of industry have expressed concerns that this latter option does not promote harmonisation.

A longer-term harmonised approach could be to opt for a ground clearance of 350 mm with some performance requirements to promote engagement of the side sills of passenger cars eg “blocker” beams in the front of LTVs. This could also improve compatibility in frontal crashes.

Some members wished to see a means of evaluating head strikes seen in crashes where LTVs strike passenger cars (eg some structure on top of the barrier element). While the “pole” test is expected to promote countermeasures such as inflatable curtains for head protection, there needs to be a means of ensuring that a range of occupant sizes are protected.

Should there be a non-struck side test?

Members agreed that there should be a test to evaluate injuries to non-struck side occupants because real world crash data attributed up to 40% of road trauma to this group depending on the geographic region. However, current dummies are unlikely to provide correct kinematics. WorldSID’s design specification is for a symmetric dummy so it is capable of measuring occupant interaction. WorldSID’s evaluation should show its capabilities in this area. Therefore it was suggested that this issue be examined by the group should it receive a mandate to continue into a 2nd phase by the IHRA steering committee.

Driver seat track position

This will depend on the dummy size used, but members expressed a desire to have the seat in the “most realistic” driving position. This may not be in the traditional mid-point position for the mid-size male and full forward position for the small female. Transport Canada undertook to provide a formula to determine seating position.

Alignment of trolley

Members wanted to see some means of defining a “worst case” situation to allow maximum penetration into passenger compartment. The current requirement is related to the R-point for a perpendicular test and it was recommended this be retained. Should a “crabbed” test be required, members were unsure whether the current targeting requirements should be retained.

Vehicle to Narrow Object (Pole) Test

The real world crash data clearly indicated that vehicle impacts into narrow objects was an area that needed to be addressed. There was considerably more consensus on the requirements of a vehicle to pole test procedure than for the MDB test. The following has been proposed:

- Moving vehicle to pole test.
- Perpendicular impact
- Speed of 30 km/h.
- Pole impact to evaluate at least head and thorax protection.
- Mid-sized adult male test device.
- Rigid pole diameter of [350 mm].
- Pole to span at least below sill height to above roof height.

The main area of discussion is the diameter of the pole and how this relates to the wish to load the head and thorax simultaneously. These two body regions were identified as being the main causes of trauma in impacts into narrow objects. A larger diameter pole is expected to better achieve head and thoracic loading at the same time as well as resulting in a more repeatable test. All regions except the USA supported a 350 mm diameter pole as proposed in the ISO test procedure. The current FMVSS 201 dynamic pole test utilises a 254 mm diameter pole.

Out-of-position side airbag evaluation

It was agreed that NHTSA and Transport Canada would draft the evaluation procedure based on ISO TR 14933 and the NHTSA/Transport Canada research. The recent work under the chairmanship of the Insurance Institute for Highway Safety would also be taken into consideration (Recommended Procedures for Evaluating Occupant Injury Risk From Deploying Side Airbags).

Sub-systems head impact test

The real world crash data indicated that head injuries were a significant part of side impact trauma even though the results of current MDB tests do not show a head injury risk. Therefore it is proposed to have a sub-systems head impact test based on FMVSS 201 and the studies performed by EEVC. Exemptions, such as those currently in FMVSS 201, will be examined should occupant protection countermeasures for the MDB and pole tests indicate that the sub-systems test is redundant (eg inflatable curtains etc).

Development of Harmonised Test Device

The WorldSID Task Group has funding and development resources for the mid-sized adult male test device only. The development of a small adult female test device would need the mandate of ISO Working Group 5. In the meantime, it has been suggested that SID-IIIs could be used, but advice will be sought from the IHRA Biomechanics group on a recommendation on the best dummies to use. It is expected that the mid-sized adult male WorldSID pre-production prototype will be ready for initial evaluation to biofidelity requirements by the beginning of 2001.

RECOMMENDATIONS FOR FUTURE WORKING GROUP ACTIVITIES

In its 2-year term, the group believes it has made good progress in proposing a set of test procedures that might form the basis of a harmonised side impact regulation.

The members believe that the following issues still need to be addressed:

- Further research to define the test parameters of the MDB test as discussed above.
- Further research to examine how to best achieve simultaneous loading of the head and thorax in the vehicle to pole test.
- Continued coordination with the WorldSID Task Group and the IHRA BWG to evaluate the harmonised test device.
- Continued coordination with the IHRA Biomechanics group to develop a set of injury criteria and for advice on suitable test devices.
- Continued coordination with the IHRA Vehicle Compatibility and Frontal groups to ensure that solutions in one area do not result in disbenefits in another.

Therefore the group is seeking an extension of the current mandate from the IHRA Steering Committee. The group believes that significant research progress can be made to finalise the outstanding issues in the areas of the MDB and pole test procedure, test dummy and injury criteria. However, the success of this work is contingent upon the commitment of resources from IHRA members.

The resolution of these issues will enable the validation phase of a new proposed side impact test procedure to begin. It is hoped that the outcomes of this

will be fed into the UN ECE regulatory process to develop a new harmonised side impact regulation.